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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

99204531.0

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

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Blatt 2 d r B scheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

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Application no.: 99204531.0
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Anmelder:
Applicant(s):
Demandeur(s):
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Bezeichnung der Erfindung:
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Titre de l'invention:
Opto-electronic device having ITO layer, SIN layer and intermediate silicon-oxide layer

In Anspruch genommene Prioriät(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)

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IVERSTAM M P (TEL:2021)

Opto-electronic device having ITO layer, SiN layer and intermediate silicon-oxide layer.

The invention relates to an electro-optical device having a ITO (indium-tinoxide layer) and a SiN layer near the ITO layer.

Electro-optical device are for instance liquid crystal display devices or image sensors.

A device of the type described in the first paragraph is known from N.C. Bird, C.J. Curling, C. van Berkel 'Large-image sensing using amorphous silicon nip diodes' in Sensors and Actuators A (1995) page 444-448 wherein a description is given of large-area image sensors. The sensors comprise a two dimensional array of pixels, each pixels comprising a photosensitive element. The photosensitive element comprises an amorphous silicon (a-Si) p-i-n or n-i-p photodiode. Light incident on each photodiode generates a photocurrent. The amount of photo-charge is subsequently transferred to drive electronics by a matrix of a-Si switching devices. A transparent ITO comprising electrode is fabricated on top of the diodes (photodiodes as well as switching diodes).

ITO electrodes are used in the opto-electronic devices because the are transparent, yet have a reasonable conductance.

A SiN layer covers at least partially the ITO layer.

Large scale image sensors include for instance X-ray imagers and contact document readers. They are (as are liquid crystal devices) usually fabricated using thin-film technology on substrates.

For a proper functioning of the devices it is important that the optical properties (in particular the transparency) and the electrical properties (in particular the conductance and capacity) of the ITO layer are well known and controlled. Variations in these properties, whether the ITO layer is used as an electrode for photodiodes or switching diodes (or more complicated structures such as phototransistors), leads to inaccuracy in the image sensors and

a in the performance of the device in particular a reduction in contrast. The same applies for LCD devices.

It is an object of the invention to provide a device of the type described in the opening paragraph in which properties of the ITO layer are better controlled or controllable.

To this end a device in accordance with the invention is characterised in that between the ITO layer and the SiN layer an intermediate layer of siliconoxide is provided.

The inventors have found that during manufacturing of the device the ITO layer is often at least partially reduced. The reduction of the layer leads to islands of metallic indium being present (or at least parts with a strongly increased metallic indium and tin content). This leads to two changes in the property of the ITO layer, the transparency is reduced and the etching properties are changed. Both of these changes reduce the quality of the device. A reduction in transparency reduces the sensitivity of the device (for sensors) or the light output of the device (LCD).

The inventors have realised that these effects occur in particular during two process steps:

When the SiN layer is provided by means of a chemical vapor deposition, this is done in a reducing atmosphere. During the deposition the already deposited ITO layer is partially (or completely) reduced forming metallic indium and tin.

Furthermore when the SiN layer has been deposited it is usually thereafter patterned by means of etching (for instance with HF). ITO which is partly reduced, will be severely attacked when it is in contact with the etching fluid for nitride etching, causing major problems for device functionality.

However, ITO, which has been protected during deposition of nitride will be fully resistant to the etching fluid for nitride etching. The etching rates for SiN and SiO are almost comparable. The intermediate SiO layer acts as a barrier preventing (or at least strongly decreasing) the reduction of the ITO layer during the manufacturing, amongst others improving the etching properties of the ITO layer, improving the optical and electrical properties of the ITO layer and thereby the quality of the device.

These and other aspects of the invention will be apparent from and elucidated with reference to the examplary embodiments described hereinafter.

In the drawings:

Figure 1 is a schematic, cross-sectional view of an optical contact document reader, in this example a fingerprint sensing device.

Figure 2 show a detail of a fingerprint sensing device.

Figure 3 shows schematically an image sensor pixel of a 2D image sensor array employing a-Si nip diodes as the matrix switch

Figure 4A illustrates the pixel circuit diagram;

Figure 4B illustrates the resulting wave forms;

Figure 5 illustrates a drive system block diagram for a 2D image sensor array.

Fig 6 is a schematic cross-sectional view of an image sensor plate for an X-ray detector in accordance with the invention.

The figures are not drawn to scale and corresponding numerals in the figures refer to the same or similar parts of a device.

Fig. 1 shows schematically a fingerprint sensing device.

Finger 1 touches the fingerprint sensing device 2. The device comprises a light source 3, a 2D array of photo-sensitive elements 4 and an optical element 5.

The finger print sensing device is, by way of example, shown in more detail in figure 2.

The device comprises a transparent substrate 21, a planar light source 3, and an optical element 5 defining optical paths. 2D array 4 having openings 28 through which light can be passed is formed on transparent substrate 21. A back light module for a liquid light crystal display ~~or~~ an EL planar light source can be utilised for light source 3. 2D array 4 is comprises a plurality of picture elements each comprising photo-sensitive element 24 and switch elements 22, interconnected by switching lines 25, signal reading lines 26 and bias applying lines 27. Optical element 5 comprises diffraction grating 32 combined with fiber members 31 and transparent protective film 33. The shapes of the components of optical elements is such that light may be focused upon a finger contacting area of transparent protective film located on center parts of openings 28. Light emitted by the light source 3 passes through openings 28 of 2D array 4 and fiber member 31, and then the light is bent by diffraction grating so that it reaches the finger contacting area of transparent protective film 33. When no finger is in contact with the surface of protective film 33, the light is totally reflected. Consequently, almost all of the light follows symmetrical light paths and reaches photo-sensitive elements 24 in the same picture elements. On the other hand, when a finger or

actually the ridge lines of the finger is (are) in contact with the surface of transparent film 33, the requirement for total light reflection is not met, and only a little light comes to photo-sensitive elements 24. Consequently ridge lines of a fingerprint can be detected because at said ridge lines the reflection is no longer total. In particular a fingerprint image is obtained. It is remarked that the invention is not restricted to the type of finger print sensor device shown in figure 2 since it relates to the layer overlaying the elements 24. Other elements of the finger print sensor are shown for illustration and may differ for different types of finger print sensors.

Figure 3 is a schematic cross section of a image sensor pixel comprising a photo-sensitive element 24 and a switching element 22. The pixel comprises electrodes 32, in this example comprising Cr (Chromium), on a base plate 31. The photo-sensitive element 24 and the switching element 22 each comprise a layer of amorphous silicon 33, respectively 34, on top of which a transparent electrode comprising ITO (Indium-tin oxide) is provided. A SiN layer 36 is provided as are aluminium lead 37. The switching diode (SD) is completely shielded from the light by the aluminium and chromium layers, while the top contact of the photo-sensitive diode (PD) is made so that light can enter through the transparent ITO electrode. The position of the column contacts 38 and the row contacts 39 is also indicated.

The arrangement of the pixel circuit in a 2D array is indicated in figure 4A, and the corresponding row addressing wave forms is indicated in figure 4B. Each row of pixels in the array is addressed periodically with a select voltage pulse of amplitude V_s and duration t_s. Considering now the situation for a pixel immediately after before the end of a select pulse, it is clear that current flowing through the forward biased switching diode 22 has charged the capacitance of the photodiode 24. Then following the falling edge of the select pulse, both diodes are reverse biased. During the interval t_f between consecutive select pulses, the photodiode capacitance is discharged by photo-current in the photodiode and this amount of charge is detected during the following select pulse when the photodiode capacitance is charged back to it starting value. The wave forms in Fig. 4B show how the pixel voltage V_p varies according to the intensity of the light incident on the photodiode.

A block diagram of the drive system utilised to acquire images in shown in fig. 5. The row drive (RD) sequentially addresses each row of pixels in the array by applying the two-level wave form described above. Charge sensitive amplifiers connected to each column detect the amount of charge required to recharge the pixel photodiodes during the select period and these amplifiers also hold the columns at a fixed potential (typically 0 V). The drive system employs LCD row driver chips. Each of the amplifier chips is connected to a A/D converter. Data are sent to a PC for subsequent processing of the image data. Figures 4 and 5

are drawn to illustrate the functioning of a type of finger print sensors, but should not be considered as restrictive for the invention which relates to the ITO electrode and the SiN layer, which may be present in other types of finger print sensor or image sensors which may use different electronic circuits.

The ITO electrode (within the concept of the invention the ITO could be doped with for instance antimony which is also called ATO (Antimony doped indium Tin Oxide)) is in contact with the SiN layer. The quality of the device and in particular the consistency of the data relies on the properties of the ITO electrode. Optical properties (transparency) as well as electrical properties (resistance) play an important role. The invention has as an object to improve these properties and in particular the reliability of the ITO layer.

To this end in between the ITO layer and the SiN layer an intermediate layer of siliconoxide (SiO_x) is provided.

For a proper functioning of the devices it is important that the optical properties (in particular the transparency) and the electrical properties (in particular the conductance and capacity) of the ITO layer are well known and controlled. Variations in these properties, whether the ITO layer is used as an electrode for photodiodes or switching diodes (or more complicated structures such as phototransistors), leads to inaccuracy in the image sensors and a in the performance of the device in particular a reduction in contrast. The same applies for LCD devices.

The inventors have found that during manufacturing of the device the ITO layer is often at least partially reduced. The reduction of the layer leads to islands of metallic indium being present (or at least parts with a strongly increased metallic indium and tin content). This leads to two changes in the property of the ITO layer, the transparency is reduced and the conductance increased. Both of these changes reduce the quality of the device. A reduction in transparency reduces the sensitivity of the device (for sensors) or the light output of the device (for LCD). An increase of the conductance leads to a changes in switching and control voltages reducing the reliability of the device.

The inventors have furthermore realised that these effects occur in particular during two process steps:

When the SiN layer is provided by means of a chemical vapour deposition, this is done in a reducing atmosphere. During the deposition the already deposited ITO layer is partially (or completely) reduced forming metallic indium and tin. Furthermore when the SiN layer has been deposited it is usually thereafter patterned by means of etching (for instance with HF).

ITO, which is partly reduced, will be severely attacked when it is in contact with the etching fluid for nitride etching, causing major problems for device functionality.

However, ITO, which has been protected during deposition of nitride will be fully resistant to the etching fluid for nitride etching. The etching rates for SiN and SiO are almost comparable. The intermediate SiO layer acts as a barrier preventing (or at least strongly decreasing) the reduction of the ITO layer during the manufacturing, thus improving the optical and electrical properties of the ITO layer and thereby the quality of the device, without introducing problems during subsequent etching.

Figure 6 shows in a cross-sectional view an image sensor plate for an X-ray detector. The image sensor plate comprises a light reflector 62 for instance comprising TiO_2 on which X-rays 61 are in operation incident. It further comprises a scintillator layer 63, for instance comprising CSI:Ti, an a-Si large area thin film electronics layer 65, which comprises ITO layers 67, a stack of layers p+ a-Si (68), intrinsic a-Si (69) and n+ a-Si (70) and metal layer 71) on a substrate 66. In between the scintillator layer 63 and the a-Si large area thin film electronics layer 65 a passivation layer 64 is provided which comprises an SiN layer 64A which is separated from the ITO layer 67 by an SiO layer 64B.

It will be clear that within the concept of the invention many variations are possible.

CLAIMS:

1. Electro-optical device having a ITO (indium-tinoxide layer) and a SiN layer near the ITO layer, characterised in that between the ITO layer and the SiN layer an intermediate layer of silicon oxide is provided.

2. Electro-optical device as claimed in claim 1, characterised in that the electro-optical device is a fingerprint sensor.

3. Electro-optical device as claimed in claim 1, characterised in that the electro-optical device is an X-ray image sensor.

ABSTRACT:

An electro-optical device such as a fingerprint sensor or an X-ray image sensor has an ITO (indium-tinoxide) layer (67) and a SiN (64A) layer near the ITO layer. In between the ITO layer and the SiN layer an intermediate layer (64B) of silicon oxide is provided. This intermediate layer prevents reduction of the ITO layer during manufacturing.

Fig. 6

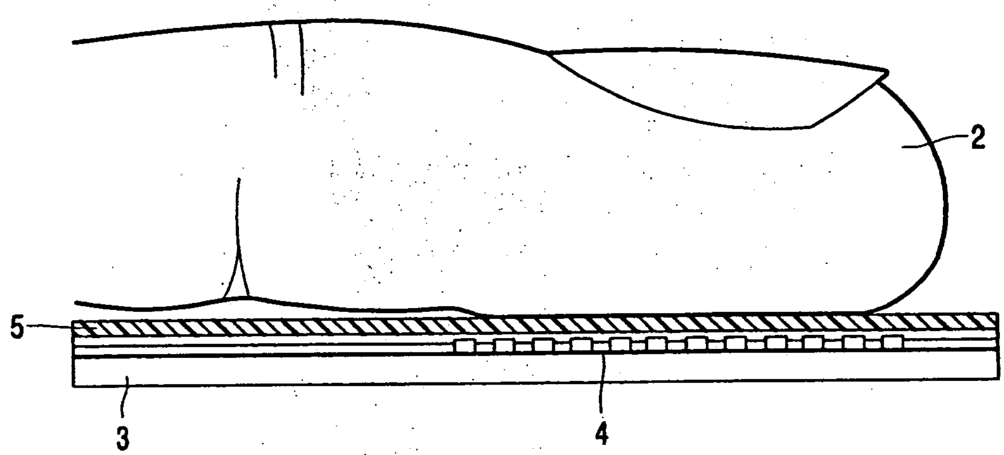

FIG. 1

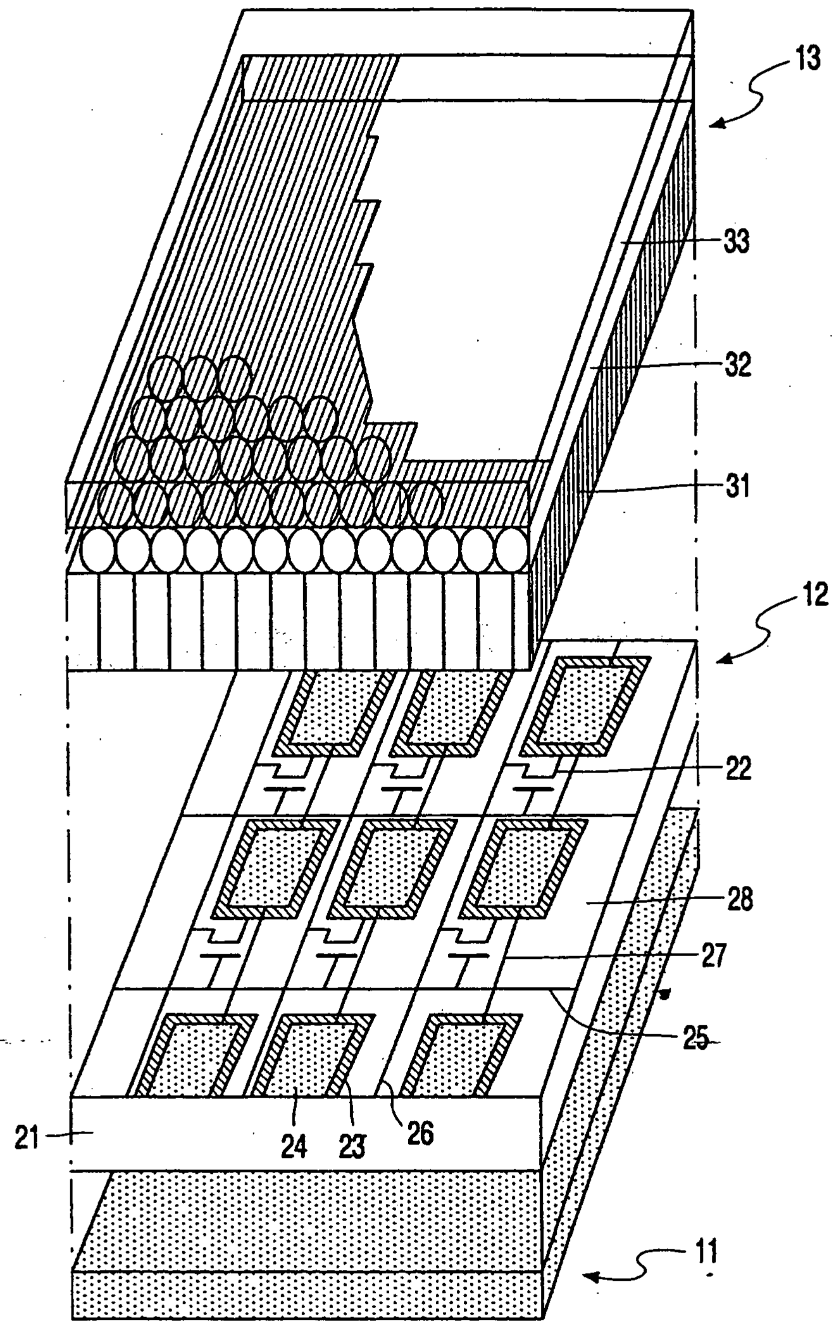

FIG. 2

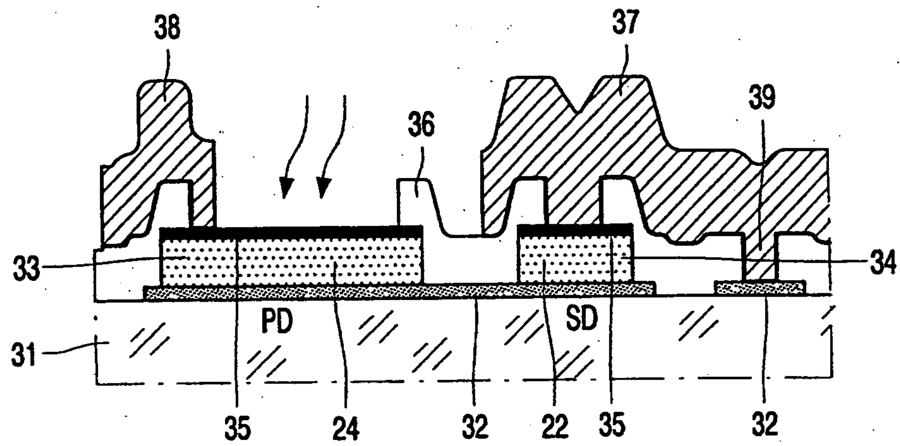
38
37
36
39
33
34
PD
SD
31
35
24
32
22
35
32

FIG. 3

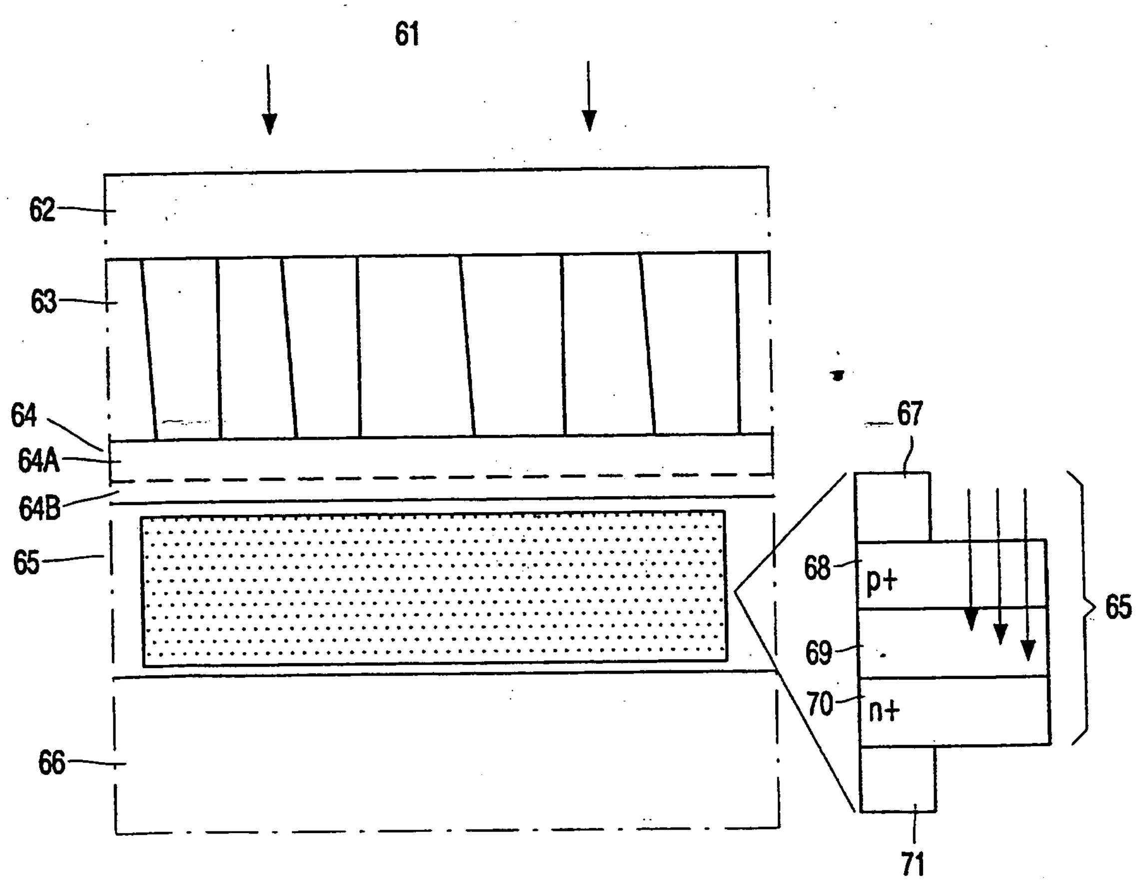
61
62
63
64
64A
64B
65
66
67
68
p+
69
70
n+
65
71

FIG. 6

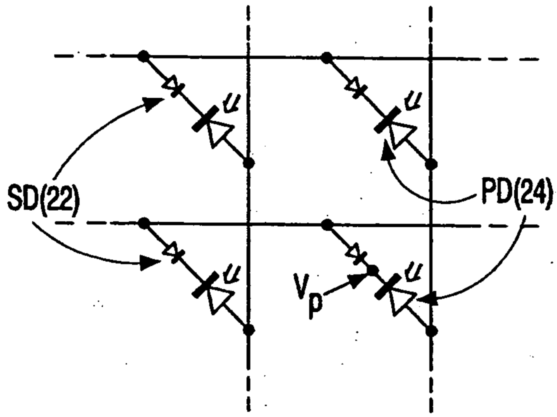

FIG. 4A

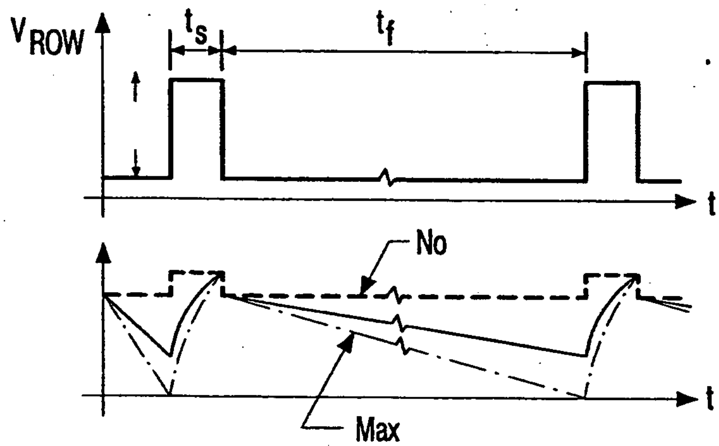

FIG. 4B

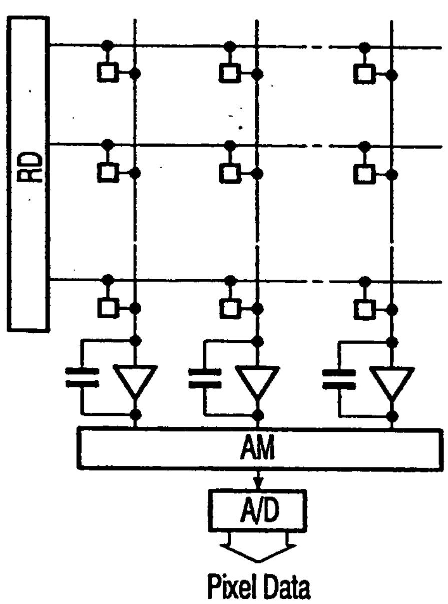

FIG. 5